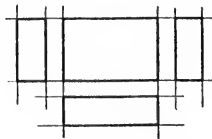
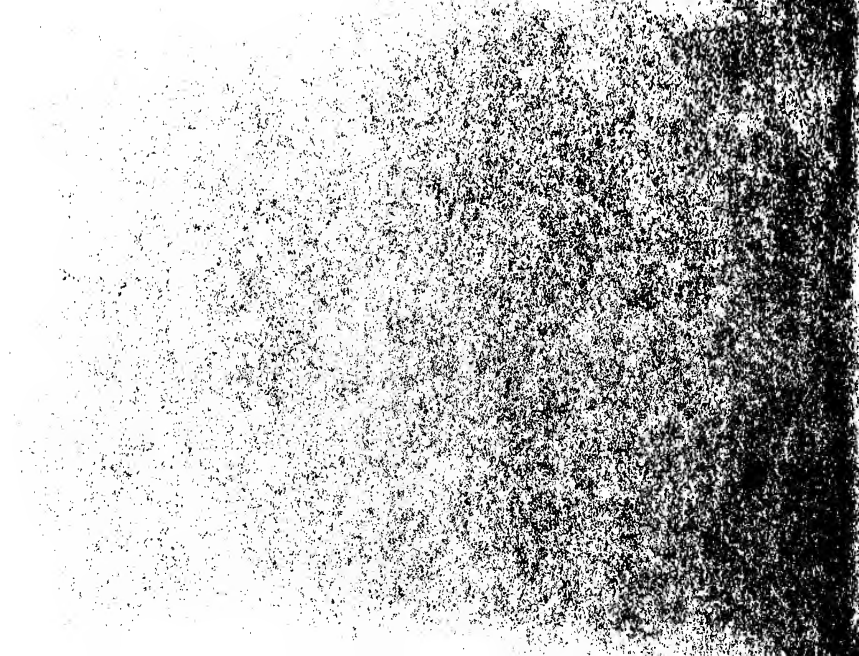




# GRAMMAR GRADE PROBLEMS IN MECHANICAL DRAWING

BENNETT





# GRAMMAR GRADE PROBLEMS IN MECHANICAL DRAWING

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## FOREWORD

This collection of simple problems in mechanical drawing has been prepared to meet an evident need in teaching the fundamentals of this subject in grammar grades.

It ought to be true that the habits formed in the first use of drawing instruments in the grammar grade classroom or workshop would never have to be unlearned, even tho the pupil became an architect, an engineer, a designer, or a draftsman, and that in so far as he learns mechanical drawing at all in these grades, he would learn what is fundamentally correct; he should learn the elements of correct expression in this universal language of the industrial world.

It ought to be true, also, that his work in mechanical drawing, while not at first following exactly the same course of models or problems as he follows in woodworking, would be parallel or closely related to the shopwork, and, in its later stages, occupy the same relation to the shopwork that the draftsman's work bears to that of the mechanic.

How to accomplish this result is the problem which this little book attempts to help solve. Alone, the book can do no more than half solve the problem, but when used under the direction of a trained and efficient teacher, it can help in forming right habits and in acquiring practical skill in simple drafting.

In the preparation of this little book the author is especially indebted to the students who have been in his classes at Bradley Polytechnic Institute during the past few years. They have suggested many of the problems, and their later experiences in teaching mechanical drawing to grammar grade classes have furnished valuable data which has been freely used in these pages.

FLORLA, ILLINOIS,

July, 1916

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## TO THE TEACHER

It is assumed by the author that in every class in mechanical drawing there will be marked individual differences in ability of pupils. This fact, however, does not demand that instruction be entirely individual. On the contrary, it is believed that far better results can be obtained, especially in the early stages of the course, if some class instruction be given. Indeed, class instruction becomes almost a practical necessity under the conditions in most schools where grammar grade boys are taught.

In order to provide for class instruction when most needed and to recognize individual capacities, the problems in this book have been arranged in groups according to fundamental stages in the process of learning to draw, and in each group there have been placed a rather wide range of problems; some are very simple, others much more difficult. *It is not expected that any pupil will work out all the problems in any one group*, but it is intended that each shall work enough to enable him to master the essential processes of the group and be prepared to proceed successfully with the problems of the following group.

The notes in each group are not intended to take the place of instruction, either class or individual, which should be given by the teacher, but they are

intended to be a valuable supplement to such instruction. From a study of these notes the teacher will readily see what principles and processes should be emphasized in each group. For example, it is easily seen that in the first group the emphasis is placed on the proper use of the tools, (a) in making measurements, and (b) in drawing the several lines constituting the lay-out of the sheet. Time and effort, on the part of both teacher and pupil, will be saved by giving plenty of drill in making lay-outs. The teacher should be sure that every pupil is forming just the right habits in this fundamental process in the first group. Teachers often fail to get satisfactory results in mechanical drawing chiefly because they are lax in this first step in the use of rule, tee-square, and triangles. Wrong habits formed here are difficult to eradicate.

After insuring the formation of correct habits of procedure in the use of instruments, the next most important concern of the teacher is to lead the pupil to gain power in visualization. The constructive imagination of the pupil must be developed. He must be led to see views of the object not shown on the paper before him, in order that he may represent them. To assist in accomplishing this purpose: (1) some of the problems are given with both the perspective view and the three

views of orthographic projection; (2) some are given with the perspective view only; (3) others present two views to find a third, which is sometimes a sectional view; and (4) still others require the student to work entirely or in part from specifications. No one of these methods of presenting a problem should be employed all the time; in order to get surest results in visualization all should be employed during the course.

The question of requiring freehand solutions of the problems before making the mechanical drawings of the problems is left entirely open to the teacher. Experience would seem to indicate that such sketching should not be a prominent part of the work of the first six groups, but may well be given emphasis in the seventh.

There is a third phase of elementary mechanical drawing which this book emphasizes; namely, lettering and the use of conventions in dimensioning. Ability to do good lettering cannot be learned in a few hours; it comes only with thoughtful and extended practice. Comparatively short exercises at frequent intervals are more interesting and more economical of time and

effort than large sheets of lettering. The lettering problems are, therefore, placed between groups of other problems instead of together. But the teacher should feel at liberty to use the lettering sheets out of the order given in the book.

The teacher who wishes to be most successful in the use of the problems in this book will consciously and continuously keep in mind the three points of emphasis mentioned above; namely:

(1) The correct method of procedure in the use of instruments, especially in making lay-outs.

(2) The progressive development of the power to visualize.

(3) Frequent, thoughtful work in lettering, and later, in dimensioning. *No dimensioning is to be done on finished drawings before Group VII.*

All the problems in this book are intended to be worked out *in pencil only*. No inking should be done until the high school is reached, or until a larger portion of time is given to mechanical drawing than is usual in the grammar grades, and not then until good work in pencil has been done.

## TO THE PUPIL

A working drawing is a business letter to a mechanic. We learn mechanical drawing in order to be able to make good working drawings. Mechanical drawing is then a kind of language, a means of transmitting ideas from one person to another. It is a form of expression that is universally understood by workmen of all nationalities. A workman in Russia or Italy or Japan can read your drawing if it is properly made, and you can read the drawings made in these foreign countries even tho you do not know a word of their spoken language.

At the present time when nearly every man hopes to build a home or a machine or a boat or a factory or some other structure, and when mechanical ideas are commonly carried from factory to customer, sometimes across the ocean, by means of mechanical drawings, it is desirable that every boy study this universal language of industry. He should at least be able to read the simpler forms of it, which he can readily do in the grammar grades, and learn to use it to some extent as a means of expressing his ideas. This book is, therefore, intended to help you in learning a new language.

## TOOLS AND SUPPLIES

Each member of the class should be supplied with the following:—

Drawing Board	{	It is desirable that these be selected with reference to accuracy and durability. To get the best results standard tee squares and triangles are essential. If, however, a lower-priced tool must be purchased the "Springfield Kit," board 19x13 in., is suggested. This is manufactured by The Milton Bradley Co., Springfield, Mass.
Tee-Square		
45° Triangle		
30°-60° Triangle		
Scale	{	Any flat foot rule accurately graduated to sixteenths of an inch will do, but it is desirable to have one that does not have graduations extending to the end. For an inexpensive rule of this type the "Nala Rule" manufactured by M. B. Bourland, Peoria, Ill., is suggested.
Compass	{	It is very difficult to find an inexpensive pencil compass with a sufficiently firm and durable joint. In the long run it is best to pay the price of a medium grade instrument of standard design, such as is sold by all drawing instrument dealers. In case this is impossible the course can be carried on, though not with the best of results, by using a very inexpensive compass of the type of Eagle No. 376 made by the Eagle Pencil Co., New York.
Thumb-Tacks		The inexpensive stamped steel tack is satisfactory.
Pencils	{	Two are needed: a hard pencil, 2H, 3H, or 4H for the lay-outs and an H or F or No. 3 for lining and lettering. To get the best results, leads or pencils of the same grade of hardness should be provided for the compass.
Pencil Eraser	{	Soft.
Drawing Paper in sheets 9x12 in.	{	This need not be a high-grade paper.
Tracing Paper (for Lettering) in sheets 6x9 in.		This may be thin bond paper used in typewriting or the inexpensive tracing paper used by architects. The only disadvantage of the latter is in the fact that it comes in rolls and must, therefore, be cut into small sheets.

# PROBLEMS

## GROUP 1

### HORIZONTAL AND VERTICAL LINES—LAY-OUT OF SHEET

**Problem 1A.** The first problem in this group is to draw three views of a block of wood that is 1" thick, 4" wide and 7" long. Fig. 1 is a perspective drawing, or picture of this block. Fig. 2 shows the three views to

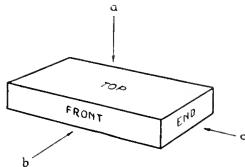


Fig. 1

be drawn. By looking at Fig. 2 again, and at Fig. 1, you will see that the top view in Fig. 2 represents what you would see if you were to look down at the block in the direction indicated by the arrow a, Fig. 1; you would see a rectangle 4" by 7". In a similar way if you were to look at the front of the block in the direction indicated by the arrow b, Fig. 1, you would see the

rectangle 1" by 7", shown in the front view in Fig. 2. You will now see what the end view in Fig. 2 represents.

Be sure to notice how these views are arranged: The front view is below the top view, and the end

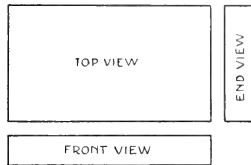


Fig. 2

view is at the end of the top view representing the end of the block where the view was taken. This is the most natural and convenient way of arranging views of blocks and many other simple objects.

Now that you understand what you are going to draw, you are ready to take a sheet of drawing paper. This should be 9" by 12". Fasten it to the drawing

board by placing a thumb-tack in each of the four corners. In doing this be sure that the lower edge of your paper is square with the left-hand end of your drawing board. Your teacher will show you how to accomplish this.

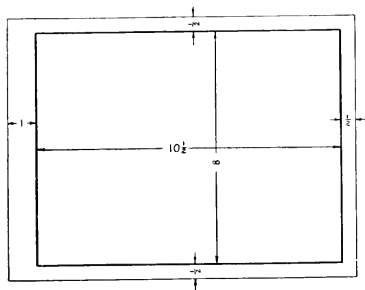


Fig. 3

To have the sheet of drawing look well when it is completed, a border line should be drawn on the sheet. It is customary to draw this border line first, and then arrange the views in the enclosed space. Fig. 3 indicates the position of this border line. The wider space at the left end of the sheet is allowed for binding the sheets together in book form at the end of the course. Three holes can be laid out and punched in the wide

space on each sheet, and all bound together with a cord or with brass fasteners.

In laying out the border line it is important that you use the instruments in just the right way. If you are ever going to do accurate and rapid work in mechan-

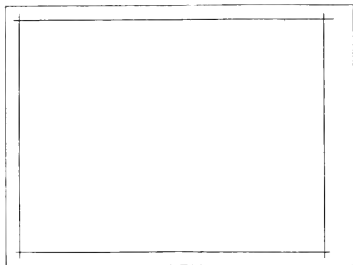


Fig. 4

ical drawing you must form correct habits in the use of the tools, and the first lesson is none too early to begin. Be very particular then to proceed as follows:

(1) With the scale placed vertically on your sheet, make a short line or mark (not a round point or dot)  $1\frac{1}{2}$ " from the bottom of the sheet, and another 8" above this one. (Habits of accurate work can be formed better by measuring from one edge of the sheet

than from both edges. Discuss this with your teacher. What will you do if your sheet does not measure exactly 9" in width?)

(2) With the head of the tee-square held firmly against the left end of your drawing board, draw a light horizontal line thru each of the marks just made. This line should extend almost the entire length of the sheet, Fig. 4.

(3) With the scale in a horizontal position on the sheet make a mark 1" from the left end of the sheet and another  $10\frac{1}{2}$ " to the right of this one.

(4) With the head of the tee-square held firmly against the left end of your drawing board and one of the triangles held firmly against the upper edge of the tee-square, draw a light vertical line thru each of the marks just made. Draw the lines long enough to cross the two horizontal lines, Fig. 4. Probably your triangle will not be large enough to draw all of the line at once. If this is the case you will have to extend the line after moving your tee-square and triangle to a new position. Be sure that the second part of the line joins accurately to the first part. Allow the horizontal and vertical lines to extend past each other at the corners as shown in Fig. 4. Remember that these lines are all to be very light.

To test the accuracy of your work, place the scale on the drawing in a horizontal position and see whether the vertical lines are just  $10\frac{1}{2}$ " apart. Then put the scale in a vertical position and see whether the horizontal lines are just 8" apart.

You are now ready to draw the three views of the block inside of the border just drawn. But before you can do this you must consider the placing of the views with reference to each other and to the border. Fig. 5 shows a satisfactory arrangement. The following

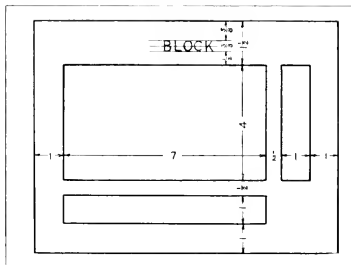


Fig. 5

facts may be noticed and may serve as a guide in later problems:—

(1) *The space between views is less than between a view and the border.* The space between the top view and the front view, for example, which is  $\frac{1}{2}$ ", is less than the space between the front view and the lower border which is 1".

(2) *The space at the left between the border and a view is the same as that between the border and a view at the right.*

(3) *Space above the views at the top of the sheet is greater than the space below the views at the bottom in order to provide a place for the title; otherwise to look well, it would be a little less instead of greater than the space at the bottom.*

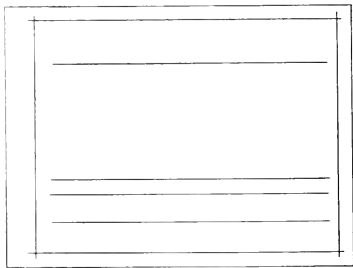


Fig. 6

(4) *The title is  $\frac{3}{8}$ " high, and is nearer to the top view than to the border. In this case it is  $\frac{1}{2}$ " from the top view and  $\frac{5}{8}$ " from the border. Fig. 5.*

With this arrangement of views and these dimensions in mind you are now ready to complete the lay-out of the sheet. *It is important that you proceed strictly according to the following directions:—*

(1) Place the scale vertically on the sheet, with one

of the main divisions of the rule, the one-inch mark, for example, on the lower border line. Then measure upward from this border line, first 1", then 1", then  $\frac{1}{2}$ ", then 4", according to the dimensions in Fig. 5, making a short mark at the end of each distance.

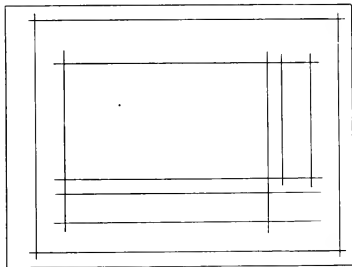


Fig. 7

(2) Thru these four marks, with tee-square, draw horizontal lines about as long as those shown in Fig. 6. *In drawing these lines make the top one first, and then work downward.*

(3) Place the scale horizontally on the sheet with one of the main divisions on the left border line, and measure distances for the four vertical lines as shown in Fig. 5.



(4) Thru the marks thus made, draw vertical lines as shown in Fig. 7. *Draw the left line first, working toward the right.*

(5) Add the guide lines for the title as shown in Fig. 5 and Fig. 8, and the lay-out is complete.

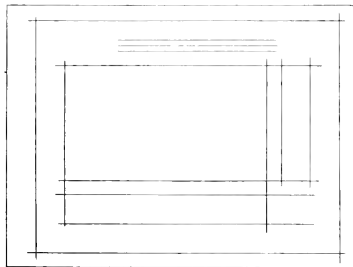


Fig. 8

the vertical lines, beginning with the left one and working toward the right. In this way you work on the sheet as a whole all the time, and not on one view at a time.

Do not erase any of the light lines left at the corners.

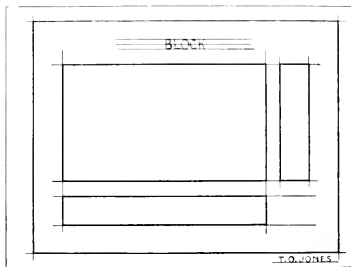


Fig. 9

The next step is to go over the border lines and the outlines of the three views with a softer pencil, making a heavier line. The effect will then be as shown in Fig. 9.

In order to form habits that will lead to speed and accuracy in this work it is important that you go over all the horizontal lines first, beginning with the top one and working down, and then that you go over

These are a sign of good technique. They indicate that you worked to cross lines instead of trying to work to points. It is far better at the beginning of the course to work without using an eraser at all.

The last step in the process of making this sheet is putting in the letters of the title as in Fig. 9. These may be put in now, or if your teacher prefers, all titles to sheets in this group may be put in after the practice

in lettering at the end of Group III. *No dimensions are to be placed on drawings in this book until you come to Group VII.*

After the drawing is completed, write your name, or letter it on a line  $\frac{5}{16}$ " below the bottom border line, and at the right-hand corner, Fig. 9.

**Problem I B.** This problem is just like the first one except that one corner is rabbeted out, Fig. 10. (1) You will therefore make the lay-out of the sheet just as



Fig. 10

you did for the first problem; see page 12 and Figs. 3 to 8. (2) Then draw the lines to represent the rabbet. If you have made the lay-out as indicated above you will have no serious difficulty in completing the front view to correspond with the other two. (3) The drawing should be finished in the same way as Problem I A, Fig. 9. No dimensions are to be placed on the finished drawing.

**Problem I c.** If you have worked Problem I B your teacher may not ask you to work this one. In working this one follow the directions given for Problem I B.

The only difference is that there are two rabbets instead of one.

**Problem I D.** This problem is a little more complex than I B and I C because the rabbet runs all the way

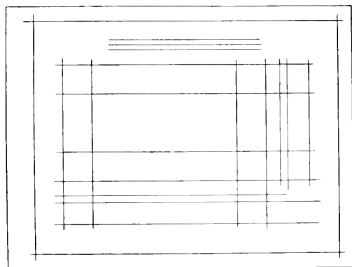
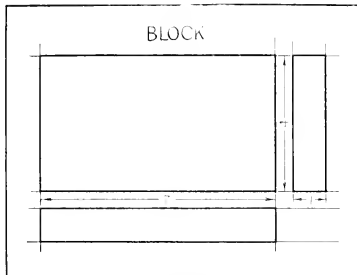
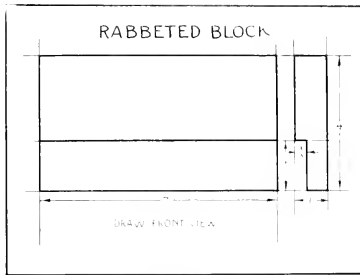


Fig. 11

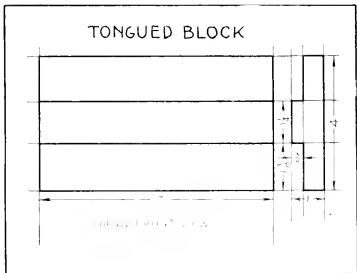
around the block. In working this problem, (1) Make the lay-out exactly as required for Problem I A, Fig. 8. (2) Then add the lines to represent the rabbet, and you will have the complete lay-out as shown in Fig. 11. (3) The drawing should be finished in the same way as Problem I A, Fig. 9.



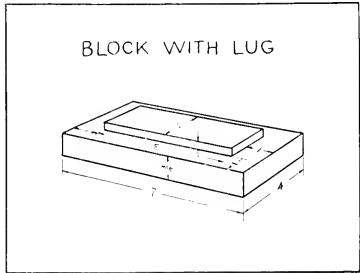
Problem I A



Problem I B



Problem I C



Problem I D

**Problem I E.** Draw top, front and end views. In working this problem, (1) Make the lay-out as required for Problem I A, Fig. 8. (2) Then add such lines as may be needed to represent the fact that parts of the original block have been cut away. Fig. 12 shows

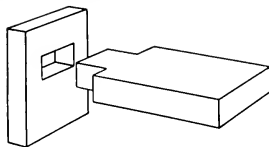


Fig. 12

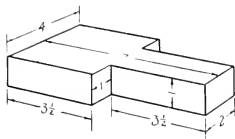
how the tenon is used in construction. (3) Finish the drawing the same way as required in Problem I A, Fig. 9.

**Problem I F.** Follow the directions given for Problem I E.

**Problem I G.** In this problem a new lay-out is required because the thickness of the block is 2" instead of 1", the width is 3" instead of 4" and the length is 5" instead of 7". These facts call for new figures in marking off the spacings for drawing lines. The following dimensions are suggested: Vertical spacings for drawing horizontal line, measuring up from the lower border line, 1", 2",  $1\frac{1}{2}$ ", 3". Horizontal spacings for drawing vertical lines, measuring to the right from the left border line,  $1\frac{1}{4}$ ", 5", 1", 2". This leaves a distance of  $1\frac{1}{2}$ " between the front and the top views, and 1" between the top and the end views, and in each case the space between views is less than between the border and the view. Finish the drawing in the same way as required in Problem I A, Fig. 9.

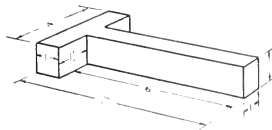
**Problem I H.** A new lay-out will be required for this problem. Study dimensions and determine each measurement in the lay-out before you begin to draw. Finish the drawing in the same way as required in Problem I A, Fig. 9.

TENON



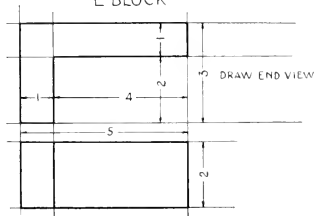
Problem 1 E

T BLOCK



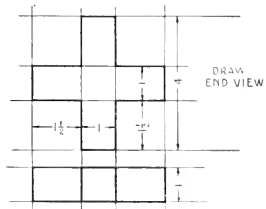
Problem 1 F

L BLOCK



Problem 1 G

GREEK CROSS



Problem 1 H

**Problem Ii.** This is one-half of an end-lap joint; see Fig. 13. A new lay-out is required for this problem. The following dimensions are suggested: Vertical spacings for drawing horizontal lines, measuring up from the lower border line,  $1\frac{3}{8}"$ ,  $1\frac{1}{8}"$ ,  $1"$ ,  $3"$ . Hori-

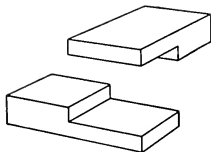


Fig. 13

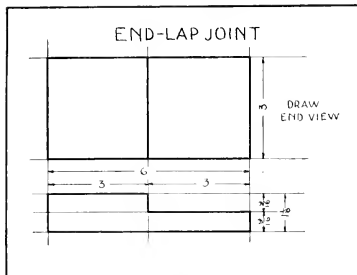
zontal spacings for drawing vertical lines, measuring to the right from the left border line,  $1\frac{1}{4}"$ ,  $6"$ ,  $7\frac{3}{8}"$ ,  $1\frac{1}{8}"$ . This leaves the distance between a view and the next one less than the distance between the view and the border. Finish the drawing in the same way as required for Problem I A, Fig. 9.

**Problem Ij.** Read the directions for Problem Ii, and modify them so that they will apply to this problem.

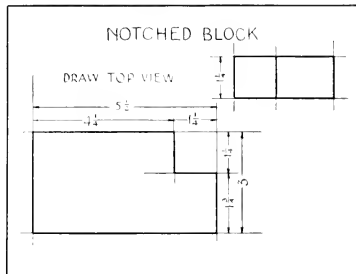
**Problem Ik.** It is not expected that very many members of the class will be able to work this problem. It is difficult to see what this block looks like. It is therefore a good test of your power to visualize. If you think you see what it is, don't ask your teacher, but test yourself by cutting the form out of wood or clay, and comparing the top and front of it with the corresponding views in the drawing.

If you have the correct form you can readily draw the end view. Space the views and finish the sheet as described under Problem Ii.

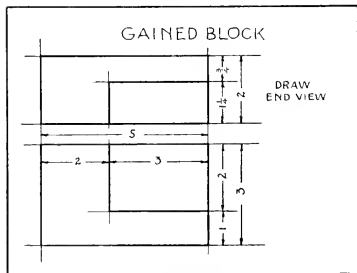
**Problem Il.** This is a good problem to test your ability to arrange the views so they will look well on the sheet and to test the accuracy of your figuring. If you are taking a course in woodworking along with this course in drawing, it is probable that you have such a cutting board on your workbench.



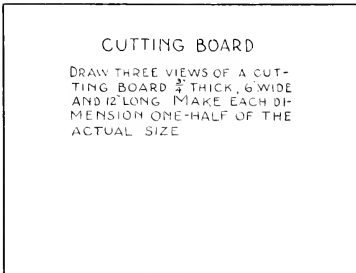
Problem 1 i



Problem 1 j



Problem 1 k



Problem 1 l

## LETTERING

**Sheet A.** The simplest letters to make are the six consisting of vertical and horizontal lines only, and the simplest way to make them is to trace them. Take a piece of tracing paper 6" by 9" and place it on Lettering Sheet A. Hold it in position, and with the soft lead pencil, trace and draw letters as directed below:

*Lines 1 and 2.* In tracing the letters in these two lines you should learn the proper *strokes* for each letter.



Fig. a

These are indicated on Fig. a. For example, the letter I should be made with a down-stroke of the pencil. H is made by two down strokes and then a horizontal from left to right. The arrows near each letter in Fig. a indicate the directions of the several strokes, and the figures indicate the order to be followed in making the strokes. It is important that you remember the order and direction of each stroke, and apply this knowledge in all your lettering.

*Lines 3 and 4.* In tracing these two lines you should use the proper strokes, but you should give special attention to the proportions of each letter. Fig. b shows the standard proportions for a letter H. By

counting the squares you will see that it is 6 units high and 4 units wide, and you will notice that the horizontal bar is just above the middle guide line. This is true of the middle bars of E and F also. In making guide lines for lettering, the top and bottom lines are always selected, and sometimes the middle line and the lines which divide the letter into thirds. See guide lines for line 7 on Lettering Sheet A. Fig. c

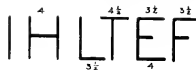


Fig. c

gives the correct proportion of each of the six letters we are now studying. H is 4 units wide; L is a little less, or  $3\frac{1}{2}$  units; T is a little more, or  $4\frac{1}{2}$  units; E is 4 units at the bottom, but only  $3\frac{1}{2}$  at the top; F is made like an E, but omitting the lower bar. In tracing you should notice the proportions of each letter. This will help you to remember the proportions of each for use later.

*Lines 5 and 6.* After you have learned the strokes and the proportions of these letters you are ready to consider spacing of letters. Fig. d shows different spacings from 5 units down to 1 unit. The question arises, which one is the best for words? It is clear

(Continued on page 21)



1 WHITEF HILT LIFE FILE

2 TITLE THEFT LITTLE E

3 HUTEF HILT FIFE FILE

4 THIEF FILE LET IF IT

5 F IT LEFT

6 HILT HEFT

7

that the 5-unit spacing is too open—in fact, open enough for the spacing between words; and it is equally clear that the 1-unit spacing is too close to look well. We will adopt the 3-unit spacing as our standard because the 4-unit space is more open than the letter itself, and the 2-unit is a little less open than the letter. The ideal spacing is obtained when the space between letters is just as open as the letters themselves, so that the eye readily passes along the word to the next space between words. But when we say that we will adopt the 3-unit space as a standard we do not mean that all spaces between letters will be 3 units. What we mean is that *the spacing will be made to look*

*just as open as two H's placed 3 units apart.* For example in the word HILT, line 3 on Lettering Sheet A, the spaces between H and I, and between I and L are 3 units, but if T were to be placed 3 units away from L it would be much too far from L to look well. As a matter of fact, the vertical line, or stem, of the T is only 4 units away from the vertical line of the L. Considering the shape of the two letters this distance gives satisfactory spacing. Notice how this same idea is applied in the other combinations of letters on the sheet. Sometimes it becomes necessary to shorten parts of letters to make the spacing satisfactory. For example, when two T's come together as in

LITTLE, Line 2, the horizontal parts of the T's should be less than  $4\frac{1}{2}$  units.

Trace the word IF, Line 5, then repeat the word IF in the space between IF and IT. Be especially care-

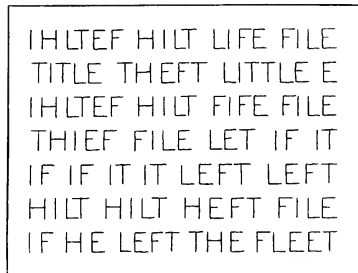


Fig. c

ful that you space the letters and the words to look well. Next trace the word IT, and then repeat it. Treat the words LEFT and HILT in the same way. Make the word FILE at the end of the 6th line.

*Line 7.* On line 7 space very carefully the phrase IF HE LEFT THE FLEET. When this has been done and you have added a border line, the entire sheet will look like Fig. c.

## GROUP II

### HORIZONTAL AND VERTICAL LINES—DASH LINES

**Problem II A.** This grooved block is made to fit the tongued block I c. It is supposed that in working problems in Group I you learned to make an accurate lay-out for a sheet, and to make the lay-out with very

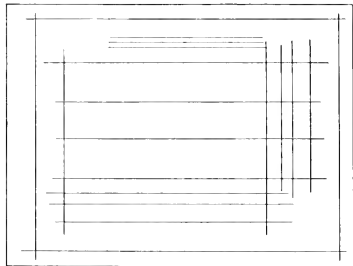


Fig. 14

light lines, so that in your drawings there is a good contrast between the finish lines and the lay-out lines. If you did not learn this, you should do so in this group, for you can never make high-grade mechanical drawings

with reasonable speed and accuracy until you learn to make a good lay-out. The general lay-out for this problem is exactly the same as the lay-out for Problem I A, Fig. 8. The completed lay-out is shown in Fig. 14. This completed lay-out is shown to let you see that the lay-out should have very light, full lines even where dash lines are to appear in the finished drawing.

As your teacher will tell you, dash lines are used to represent hidden edges. Such lines are often called

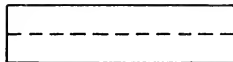


Fig. 15

dotted lines, but really they are not dotted lines at all, for they consist of short dashes. These dashes, when properly made, should be a little longer than the spaces between the dashes. The exact length of the dashes cannot be definitely stated for all kinds of drawings, because the lengths of the dashes vary according to the size of the drawing. For most of the work in this book a dash that is about  $\frac{1}{8}$ " long, followed by a space that is about  $\frac{1}{16}$ ", will be satisfactory. Fig. 15

illustrates such a dash line. It also illustrates how a dotted line should begin and end. It should begin with a dash and end with a dash unless it is the continuation of a full line, in which case it should begin

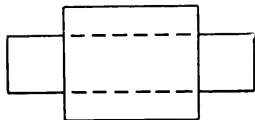


Fig. 16

with a space, Fig. 16. Be sure to remember this; your drawings will look better if you do. In putting in the dash lines, the dashes should be made nearly as heavy as the finish lines of the drawing. These heavy, pencil, finish lines of the drawing correspond to the ink

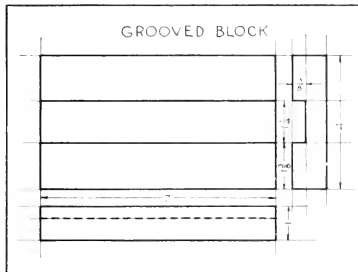
lines which are used by draftsmen and in more advanced school work.

**Problem II B.** This stand, Fig. 17, is made of five pieces of wood—the top and the four legs. The grain of the wood in the legs runs the same way as in the top, and the legs are glued on. This kind of a joint, when the leg comes out flush with the edge of the top, is not usually shown on the drawing. In other words the drawing is made just the same as it would be if the stand was cut out of one piece of wood.

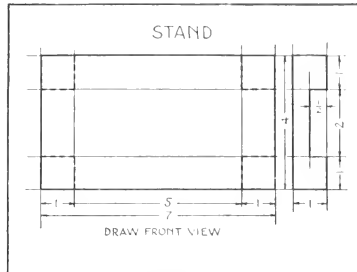
In the top view, Page 27, is a good illustration of how dash lines should join each other—dash meeting dash. Dash should not meet space nor space meet space.

**Problem II c.** This problem is similar to Problem II A, but requires a different lay-out.

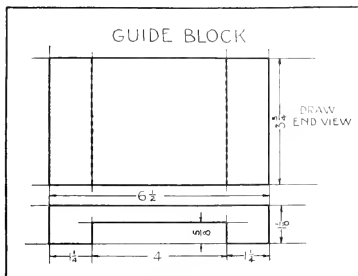
**Problem II D.** Draw top, front, and end views. The problem gives good experience in drawing dash lines.



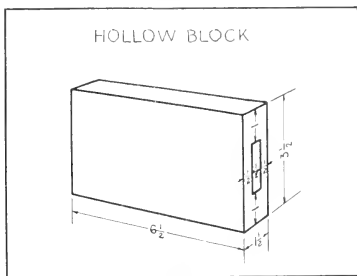
Problem II A



Problem II B



Problem II C



Problem II D

**Problem II E.** Up to this time in arranging views on the sheet, you have placed them as shown in a, b, c, Fig. 18; the top view, a, is above the front view, b; and the end view, c, is at the right of the top view. But in drawing the dado joint there are other arrangements of views that are better. The placing of views as in d, e, f, is better because less space is required for the drawing and because it seems more natural to see the end view in the position, f, than in the

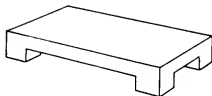


Fig. 17

position c. It often seems desirable to show the left end of an object instead of the right end. In such a case the end view is placed at the left as in g. In other words a right end view is always placed at the right of the front view (or at the right of the top view, as the case may be) and the left view is placed at the left.

Furthermore, it is often true that no more than two views of an object are needed to tell all we need to know about it. This is the case with the dado joint. If you were to omit either the top view, h, or the end view, g, you would still have all the facts shown that you would need in making the joint. But you cannot

omit both h and g. Why? On your sheet draw two views only, as shown in j and k.

**Problem II F.** Read about the selection of views under Problem II E. In the forked joint we may select c, Fig. 19, and any one of the other three views

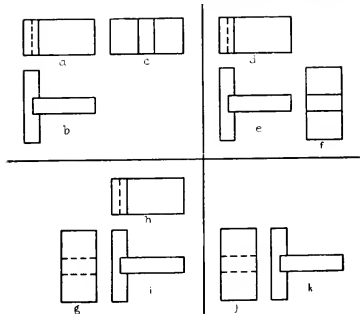
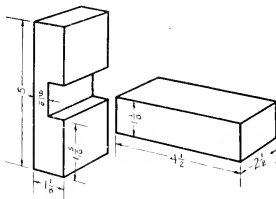


Fig. 18

shown. In this case the views b and d are just alike. Why would you select b or d instead of a? You may draw c and d on your sheet.

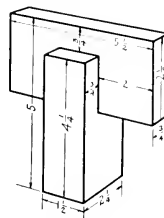
**Problem II G.** Read about the selection of views under Problem II E. Draw the two views of the mortise-and-tenon joint that tell the most about it and

DADO JOINT



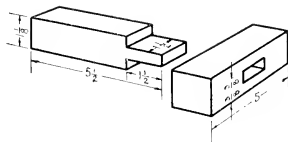
Problem II i

FORKED JOINT



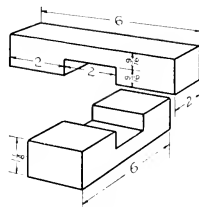
Problem II r

MORTISE-AND-TENON JOINT



Problem II c.

CROSS-LAP JOINT



Problem II n

tell it in the simplest, clearest way. In your drawing show the two parts put together.

**Problem IIH.** Read about the selection of views under Problem II I. Draw the two views of the

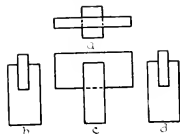


Fig. 19

cross-lap joint that tell the most about it in the simplest way. In your drawing show the two parts put together.

**Problem II I.** The usual method of laying out a cross-lap joint in the shop is shown in Fig. 20. This

shows a piece of stock somewhat longer than the two parts of the joint in order to give space for sawing off the ends square. The lines on the views in the draw-

ing show the knife and gage lines on the stock when properly laid out. Make a similar lay-out drawing for the middle-lap joint.

**Problem II J.** Draw top and front views of the bench hook.

**Problem II K.** We have an oilstone  $1\frac{5}{16}$ " thick,  $17\frac{1}{8}$ " wide,  $57\frac{7}{8}$ " long, and wish to make a box or case for it such as is shown in the perspective drawing. The stock from which the case is made is  $\frac{5}{16}$ " in thickness. The stone projects  $\frac{7}{16}$ " above the upper edge of the case. Make a drawing showing the top and front views of the case with the stone in it.

**Problem II L.** Draw the front and top views of a box whose inside dimensions are  $1\frac{1}{4}$ " deep,  $1\frac{3}{4}$ " wide,  $7\frac{1}{2}$ " long, and the stock for which is  $\frac{1}{2}$ " in thickness.

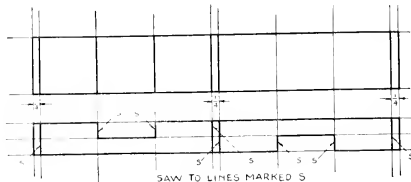
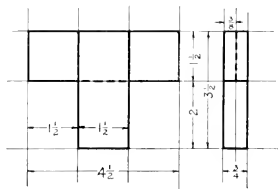


Fig. 20

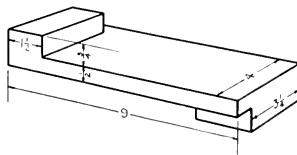


MIDDLE-LAP JOINT



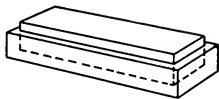
Problem II i

BENCH HOOK



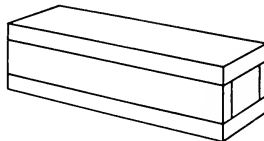
Problem II j

OILSTONE



Problem II k

BOX



Problem II l

## LETTERING

**Sheet B.** This lettering sheet is planned to be used in the same way as Lettering Sheet A. Take a piece of tracing paper 6"x9" and place it on the sheet. Hold it in position, and with the soft pencil, trace and draw letters as follows: -

*Lines 1 and 2.* In tracing the letters of these two

top than at the bottom. In K and X the  $3\frac{1}{2}$  units are measured from the left upper corner; in the Z from the right upper corner. Notice that the angular openings on V, A and W are all different: The V is  $4\frac{1}{2}$  units, A is 5, and W,  $3\frac{1}{2}$ .

*Lines 5 and 6.* These lines constitute an exercise



Fig. f



Fig. g

lines be sure to make strokes in the order indicated in Fig. f. Learn the order of strokes for each letter.

*Lines 3 and 4.* While tracing these two lines make a study of the proportions of each of the letters. These proportions are indicated by the numbers in Fig. g, and are readily shown by the guide lines and spacing lines on the sheet. Notice that the third stroke in K is part of a line drawn from the upper left corner of the letter to the lower right corner, Fig. g. Notice also that the K, the X and the Z are narrower at the

in spacing. Re-read the discussion of spacing under "Lines 5 and 6" of Lettering Sheet A before beginning to trace line 5. Trace the word MAN and then repeat it in the space left before the next word, taking special care to have the letters properly spaced and the word as a whole placed in the middle of the space available. The words THE, WET, and MAY should be treated in the same way.

*Line 7.* On line 7 space very carefully the sentence WE MAY WALK AWAY. Add border line to finish the sheet.

1 N M K V A W X Y Z I W A L K

2 L A T H E V E L V E T V A N

3 N M K V A W X Y Z W I T T Y

4 N A M E W A L K K N A V E

5 M A N T H E

6 W E T M A Y

7

## GROUP III

### INCLINED LINES—FORESHORTENING—USE OF TRIANGLES

**Problem IIIA.** This problem would be like some of the problems in Groups I and II were it not for the inclined line. This line is drawn with one of the triangles used as a straight-edge. The only real difficulty in the problem is in understanding the end view. The lower part of this view represents a receding surface; that is, a surface that slopes back; or, as we usually say, the surface is foreshortened. If you follow the plan of making the lay-out as you were instructed to do in the first two groups you should

have no trouble in determining the length of foreshortened surfaces. It is readily accomplished by projecting directly across from one view to another.

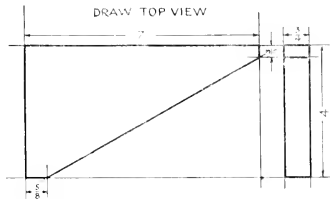
**Problem IIIB.** This is an angle block such as is used by machinists. Draw the top, front and end views. Give special care to the lay-out.

**Problem IIIC.** Draw the two views of this angle block that tell most about it in the simplest way.

**Problem IIID.** In working this problem be sure to make a careful lay-out.

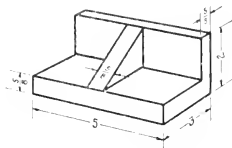
# SHELF BRACKET

DRAW TOP VIEW



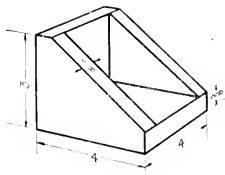
Problem III A

# ANGLE BLOCK



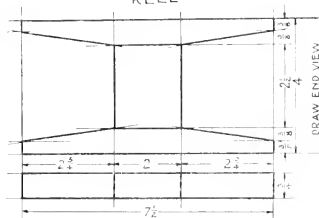
Problem III B

# ANGLE BLOCK



Problem III C

# REEL



Problem III D

**Problem III E.** This kind of a corner block is used by cabinet-makers to stiffen pieces of furniture. It is glued into an inside corner. The new feature of this problem lies in the fact that the acute angle is  $45^\circ$  and can therefore be drawn with the  $45^\circ$  triangle placed against the tee-square.

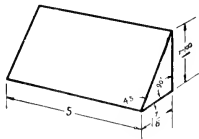
**Problem III F.** Select and draw two views of the

miter joint. Notice that the acute angle at the corner must be  $45^\circ$ . Why?

**Problem III G.** Since the acute angle in this frame is  $60^\circ$  the inclined lines may be drawn with the  $30^\circ$ - $60^\circ$  triangle held against the tee-square.

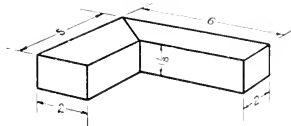
**Problem III H.** Draw the top, front and end views of the cord winder.

## CORNER BLOCK



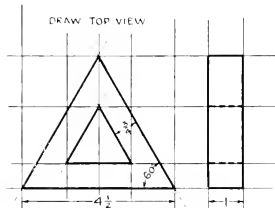
Problem III b.

## MITER JOINT



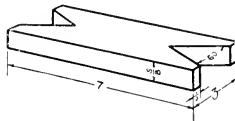
Problem III c

## TRIANGULAR FRAME



Problem III e

## CORD WINDER



Problem III f

**Problem IIIi.** In making the lay-out for the top view, draw a horizontal center line. In this way the intersection of the lines making the acute angles are readily found.

**Problem IIIj.** Draw the top and front views of the bench stop.

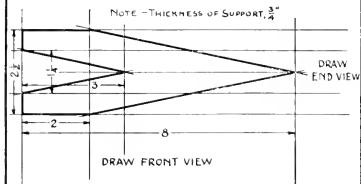
**Problem IIIk.** This is intended to give some good experience in the use of the  $30^{\circ}$ - $60^{\circ}$  triangle, as well as

provide a test of your grasp of the principle of foreshortening. The drawing should be made to a scale of  $6''=1'$ . That is, each line should be drawn half the length indicated by the figures. Your teacher will tell you more about drawing to scale.

**Problem IIIl.** Using the given molding, draw two views of a picture frame for a picture that is  $8\frac{1}{2}''$  by  $12\frac{1}{2}''$ . Make drawing to scale of  $6''=1'$ .

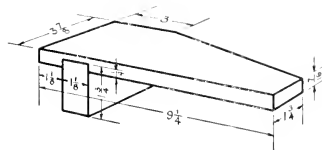


### HOSE NOZZLE SUPPORT



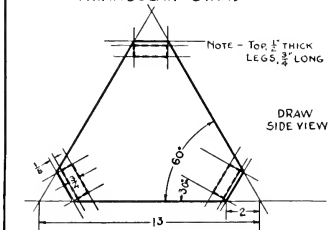
Problem III i

### BENCH STOP



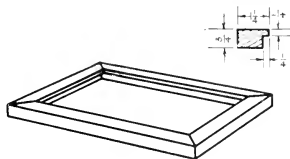
Problem III j

### TRIANGULAR STAND



Problem III k

### PICTURE FRAME



Problem III l

## LETTERING

**Sheet C.** This sheet follows naturally after Lettering Sheets A and B, and completes the alphabet. The plan of procedure is just the same as in the others. Take a piece of tracing paper 6" by 9" and place it on

also, that the middle bar of the B is above the middle guide line while the corresponding bars of P and R are below that line. The proportions of the letters are indicated in Fig. i. Fig. j shows six letters which



Fig. h



Fig. i

the sheet. Hold it firmly in position, and with the soft pencil trace and draw letters as follows:—

*Lines 1 and 2.* While tracing these two lines you

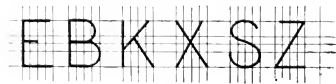


Fig. j

are expected to learn the strokes of all the curved letters; see Fig. h.

*Lines 3 and 4.* In studying the proportions of the curved letters, notice that the O and Q are each a little more than 4 units wide. It should be observed,

should be associated together in trying to remember their proportions. All of these letters are a half unit shorter at the top than at the bottom. The first five all line up to a vertical on the left, while Z alone lines up on the right. Remember this.

*Lines 5 and 6.* The treatment of these lines is the same as in previous sheets. Repeat the words COGS in the space following it. Then repeat JUG and GUDGEON, being especially careful to get good spacing.

*Line 7.* For this line select a text, motto, sentence or phrase that will fit nicely into the space. Estimate the spacing carefully before you begin to do the lettering. You can do this by making a trial copy on an extra sheet of paper.

1 OQCGUJDPBRS RUG

2 GOUGES PROUD UP

3 OQCGUJDPBRS RUG

4 GOUGES PROUD UP

5 COGS JUG

6 GUDGEON

7

## GROUP IV

### THE OCTAGON AND THE HEXAGON

**Problem IVA.** In drawing the octagon consult Fig. 21. Start with the line a b, which in this case should be  $2\frac{1}{8}"$  long. The entire figure is to be drawn with the  $45^\circ$  triangle and the tee-square. Draw the lines in the order indicated in Fig. 21. The first is

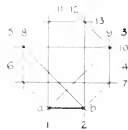


Fig. 21

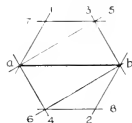


Fig. 22

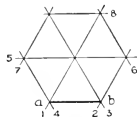


Fig. 23

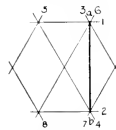


Fig. 24

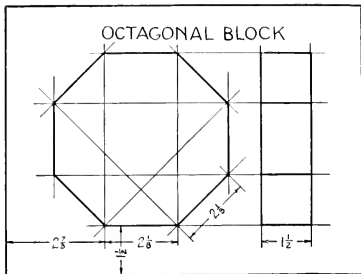
a vertical line thru a, the second a vertical line thru b, the third a line from a, inclined upward to the right, the fourth a similar line thru b, etc. Notice that in order to draw the horizontal line 7 you must measure  $2\frac{1}{8}"$  up from b along the line 4. Finish the drawing as in previous groups.

**Problem IVb.** The process in drawing this hexagon is similar in some respects to Problem IV A, except that the  $30^\circ$ - $60^\circ$  triangle is used. Notice that the diagonal of the hexagon,  $5\frac{1}{2}"$ , is the only dimension given for that view. This diagonal is represented by

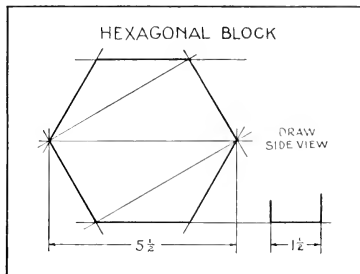
the line a b in Fig. 22. With the triangle against the tee-square, draw the lines in the order indicated by the figures 1, 2, 3, 4, etc. To show the thickness of the block the lower end of the side view is drawn. You are to complete this view. Notice how many

degrees each line you draw with the triangle makes with a horizontal line.

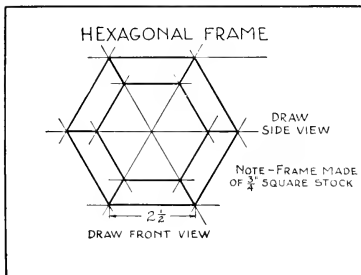
**Problem IVc.** In its method of procedure this problem is similar to the two previous ones. In this case, however, one side of the hexagon, instead of its diagonal, is given. In Fig. 23 this side is represented by the line a b. Draw the other lines of the figure as indicated by figures in Fig. 23. To draw the inner edge of the frame, measure in from the outer hexagon a distance equal to the thickness of the stock, and draw the lines of the figure. Be sure to measure perpendic-



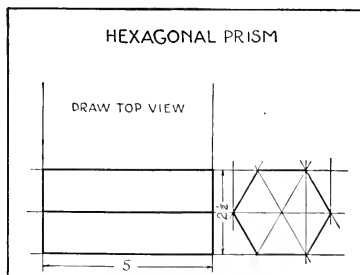
Problem IV A



Problem IV B



Problem IV C



Problem IV D

lar to the sides, and not on the diagonal lines at the corners.

**Problem IV D.** In drawing the hexagonal prism with the diameter given you have a problem that is very common in practical drafting. The given distance

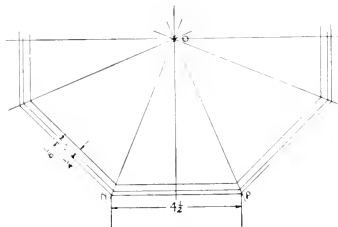


Fig. 25

is represented by the line *a b* in Fig. 24. Draw the lines in the order indicated.

**Problem IV E.** Draw the octagon on a waste piece of paper so as to be able to locate it in just the right place on the sheet. See Problem IV A.

**Problem IV F.** See Problem IV D.

**Problem IV G.** This problem is a test of your knowledge of the process of drawing an octagon and of the accuracy of your work. The drawing is to be made to a half scale,  $6'' = 1'$ , in order to go on your sheet conveniently, and even then it will be desirable to draw the right-hand side view instead of the front

view. After you have drawn the outside octagon representing the outer edge of the tray, measure perpendicularly in from each side  $\frac{1}{8}''$ , then  $\frac{1}{4}''$  in from that, as shown in Fig. 25. After this has been done, draw lines thru all of these points parallel to the cor-

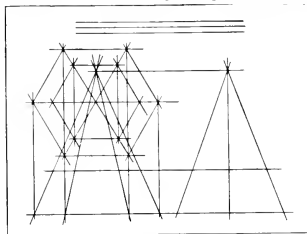
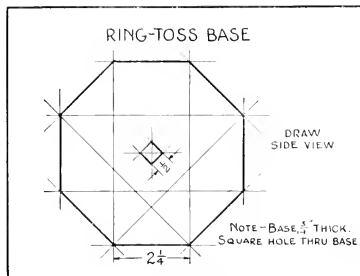


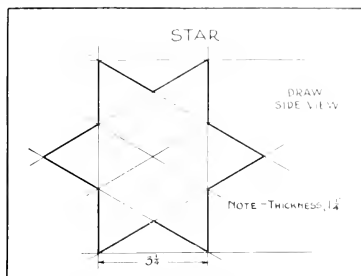
Fig. 26

responding sides of the octagon. These lines should meet on lines drawn from the corners to the center of the octagon. Test the accuracy of your work by drawing lines, as *ON* and *OP*, Fig. 25.

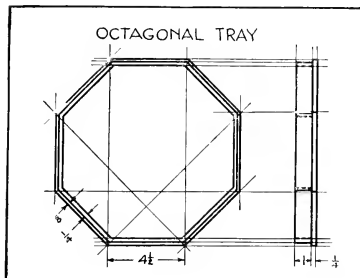
**Problem IV H.** In working this problem you will find it desirable to make the front and side views of the entire pyramid in the lay-out. This is the easiest way to get the lines representing the sloping sides drawn at the proper angle. When drawn in this way the front view in the lay-out will overlap the top view, Fig. 26. You will readily see, however, that the truncated part to be lined in does not overlap.



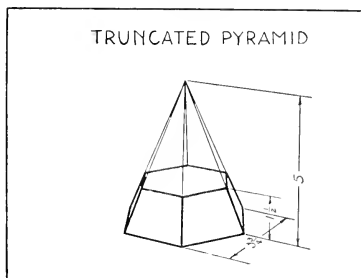
Problem IV e



Problem IV f



Problem IV g



Problem IV h

## LETTERING

**Sheet D.** The first three lines of this sheet are all figures and they are to be treated as follows: Trace the first line to learn the strokes, Fig. k. Trace the second to study the form and proportions of the figures.

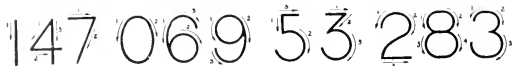


Fig. k

You will see that there are two styles of 3 given, one based on the 8 and the other on the 5. Either style is permissible. Trace the third line with special reference to spacing, repeating each of the two groups.

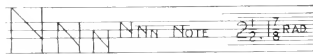


Fig. l

On the fourth line space carefully, so as to occupy the full line, the following figures:—8932490756382910.

On the remaining three lines letter such a selection as may be approved by your teacher. It may or may

not include figures. Either in this selection or in practice work following this sheet, before you reach Group VII, you should work with smaller letters and figures. Fig. l suggests sizes of letters you can readily

make with the guide lines on the present sheet. It also shows how by the addition of a few intermediate lines it is possible to make guide lines for a variety of work. Notice especially the spacing for fractions.

A good plan in learning to make the smaller sizes of letters is (a) to change from the  $\frac{3}{8}$ " to the  $\frac{1}{4}$ " size. (b) Next try the  $\frac{3}{16}$ "; (c) then the  $\frac{1}{8}$ ".

Here is an extra problem that may interest you. Draw guide lines on a sheet of paper and carefully letter the following:—

“THE LOVING EYE  
THE SKILFUL HAND  
SHALL WORK WITH JOY  
AND BLESS THE LAND”



1 | 4 7 0 6 9 8 3 5 3 2 9 6 7

2 | 4 7 0 6 9 8 3 5 3 2 9 6 7

3 | 8 3 5 2 4 7 0 |

4

5

6

7

## GROUP V

### THE CIRCLE—CENTER LINES—SECTIONS

**Problem VA.** Before you draw a circle you must find the center of the circle. The most common method of finding the center is to draw lines intersecting at the center. Such lines are called center lines. They should be light lines.

Another important thing to remember in drawing circles is to test the setting of your compass. This is



Fig. 27

readily done by drawing on a scrap piece of paper a circle, or short arcs on opposite sides of the center, as a and b in Fig. 27. If the distance from a to b, measured thru the center o, is the measurement desired, the compass is properly set. If not, change the setting of the compass, and test again. When the compass is set be sure you do not change it in putting the needle-point into the paper or in drawing the circle. Your teacher will show you just how to do this without danger of error. In drawing the target, test the setting of the compass for each circle; when drawn test all your circles by laying the scale on the drawing.

Beginning with this group we have a new order in finishing drawings:—

1. Line in the circles and arcs of circles.
2. Line in all horizontal lines, beginning at the top of the sheet and working down.
3. Line in all vertical lines, beginning at the left of the sheet and working toward the right.
4. Line in inclined lines, taking those of the same angle together.
5. Letter the title.

Be sure to remember this order because it is important that you form the habit of working in this way in order to acquire speed and accuracy.

**Problem VB.** In making your lay-out for this and other problems draw the im-

portant circles first, and project from the circles to the other views. Never reverse this process.

For example, the circle O, Fig. 28, represents the

(Continued on page 57)

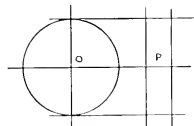
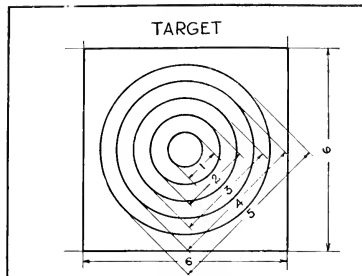
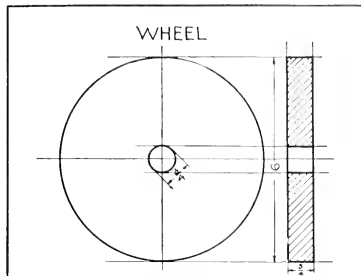


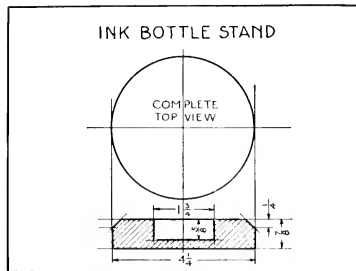
Fig. 28



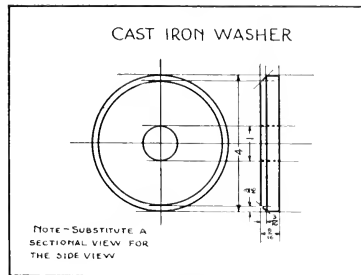
Problem V a



Problem V b



Problem V c



Problem V d

face view of a circular disc, and the rectangle P represents the side view. Always draw the circle O first, and project across to draw the top and bottom lines of the side view. If the reverse of this process were attempted any slight error in measuring the length of the rectangle or in locating the center O or in setting the compass would prevent the projection lines from joining the circle at the tangent points. The circle is therefore drawn first and drawn accurately. Be sure to test your setting of the compass.

The drawing of the cart wheel shows the face view of the wheel and a sectional view. The sectional view, or section, is commonly used in representing round objects, or objects of revolution, as they are technically termed, because a section thru the center, or axis of revolution, usually tells more about the object, or tells it better, than any other view. A section is represented by drawing lines at an angle of  $45^\circ$ , sloping either to the right or to the left, at an even distance apart. Drawing these lines is called cross-hatching. The purpose of this cross-hatching is the same as that of tinting a surface; it enables the eye to readily distinguish the particular surface cross-hatched.

In describing a section we say that it is "taken" at a certain line or thru a certain point. This one, for example, is a vertical section taken thru the center of the wheel. This section represents what you would see if the wheel were cut vertically thru the center, and you were looking directly at the surface cut.

**Problem Vc.** This problem is similar in purpose to Problem Vb.

**Problem Vd.** The main purpose of this problem is to give experience in substituting a sectional view for a side view.

**Problem Ve.** This problem is a study of cylinders at right angles to each other—a cylindrical mallet head with a cylindrical hole in it.

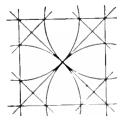


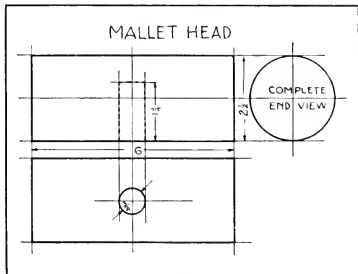
Fig. 29



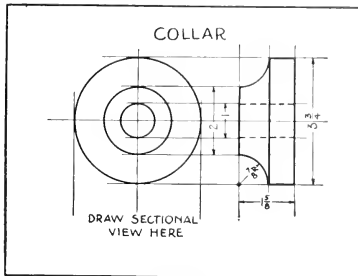
Fig. 30

**Problem Vf.** Just as intersecting center lines determine the centers of circles, so cross lines determine the centers of arcs of circles. In this drawing of the collar the centers of the  $\frac{7}{8}$ " arcs are found beforehand if the lay-out is made properly.

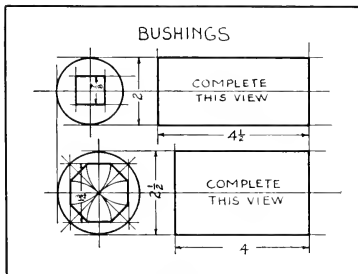
**Problem Vg.** In making drawings of the bushings your teacher will indicate whether you need most to make sectional views or side views; either will satisfactorily represent the object. In drawing the octagon of the second bushing either of the following methods may be employed because the diameter is the dimension given: (1) It may be drawn within a square of the same diameter, Fig. 29. Draw the square, and its



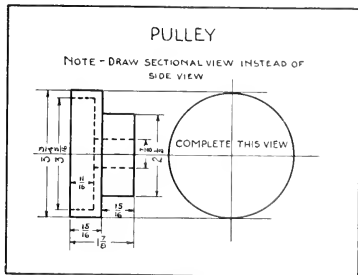
Problem V E



Problem V F



Problem V G



Problem V H

diagonals, then, using the corners of the square as centers, strike arcs with radius equal to half of the diagonal. (2) It may be drawn outside of, or circumscribing a circle of the same diameter as the octagon, Fig. 30. Draw all four of the diameters as shown in the figure so as to find the exact points on the circle thru which to draw the sides of the octagon. These sides are tangents to the circle at the points where the diameters intersect the circumference of the circle.

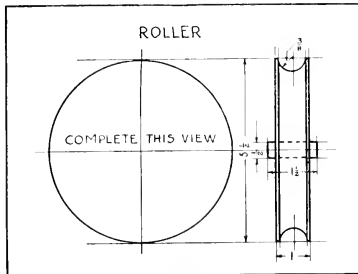
**Problem Vh.** This problem requires both the completion of a front view and the substitution of a sectional view for a side view.

**Problem Vi.** Be sure to draw the vertical center line which determines the centers of the half-circles.

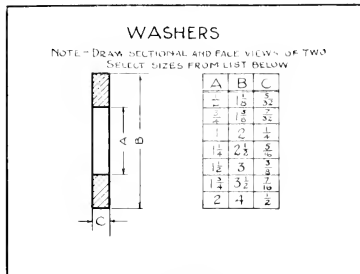
**Problem Vj.** This problem gives you an opportunity to work from a "data sheet." Your teacher will indicate which two sizes of washers you are to draw or will allow you to select. In this problem the term "face view" is intended to mean the same as the term "front view" used in previous problems.

**Problem Vk.** Consult your teacher concerning which of these you should draw.

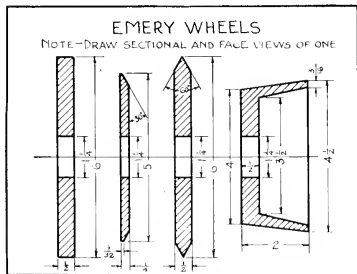
**Problem Vl.** Read the directions carefully. Notice that it is the picture, not the frame, that is  $3\frac{1}{2}"$  in diameter.



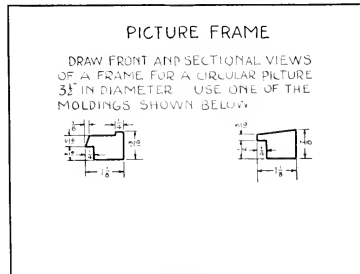
Problem V i



Problem V j



Problem V k



Problem V l

## GROUP VI

### TANGENTS

**Problem VIA.** If you wish to avoid difficulties in drawing tangents, *always find the exact point where the straight line joins the circle*, or in the case of two circles, just where one circle ends and the other begins. This

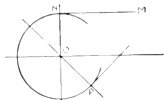


Fig. 31

will save you a great deal of trouble. For example in drawing the line NM, Fig. 31, tangent to the circle O, it is important to find the point N so that you may know just where to take up your compass in lining in

the circle and just where to begin lining in the straight line NM. In this case it is easy to find N because NM is a horizontal line. N is therefore in a vertical line drawn thru O, the center of the circle.

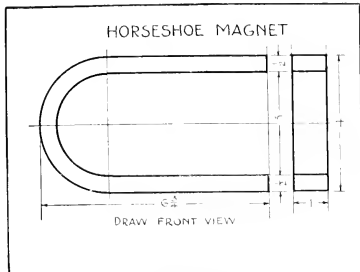
In drawing the horseshoe magnet (1) draw the horizontal center line first, (2) next the vertical center line, (3) then the two circles, (4) after which it is easy to draw the horizontal lines, and (5) finally the vertical lines. In lining in follow the order described in Problem VA.

**Problem VIb.** The same general directions given for Problem VIA apply in this one.

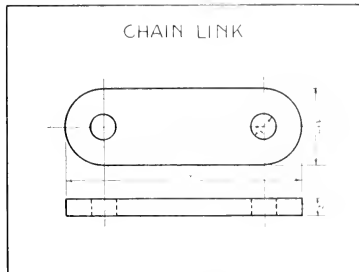
**Problem VIc.** See general directions under Problem VIA.

**Problem VId.** See general directions under Problem VIA.

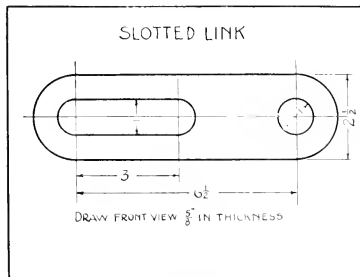




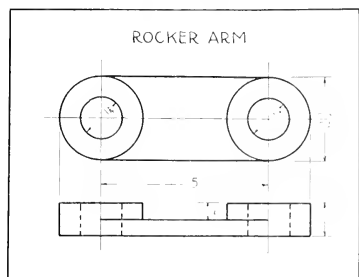
Problem VI A



Problem VI B



Problem VI C



Problem VI D

**Problem VIE.** See general directions under Problem VIA.

**Problem VIF.** See general directions under Problem VIA.

**Problem VI G.** In this problem it is more difficult to find the points of tangency because the straight lines are not horizontal. The method is shown in Fig. 32. Notice that the 45° triangle, shown in dash lines, is first placed up against the two circles; then its position is changed so that a line can be drawn thru the center and the point of tangency.

Notice also that points of tangency thus found are used in determining the length of one of the lines in the front view.

**Problem VI H.** The drawing of the faceplate presents another new problem: to find the center of an arc of given radius that will be tangent to two straight lines which are at right angles with each other, or in other words, to draw an arc in a square corner. Fig. 33 shows the process:—With the given radius and *a* as center, strike the arc *bc*. With the same radius and *b* and *c* respectively as centers, strike arcs intersecting at *d*. With *d* as a center, strike the required arc.



Fig. 33

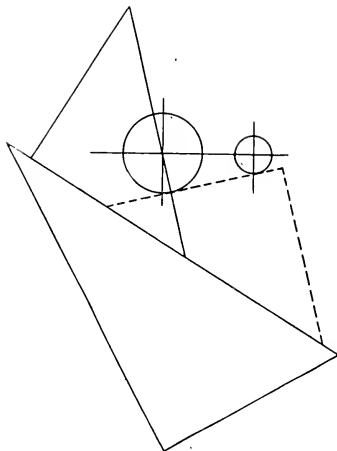
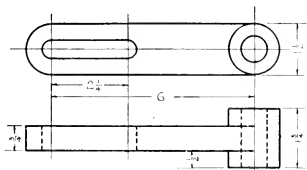


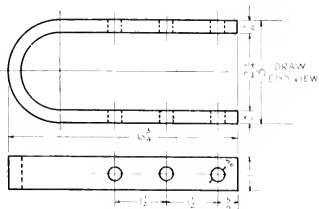
Fig. 32

ROCKER ARM



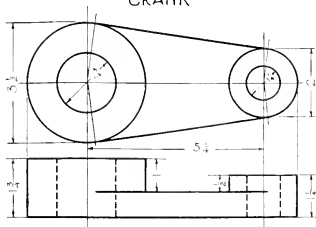
Problem VI c

STRAP



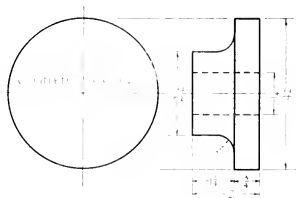
Problem VI e

CRANK



Problem VI g

FACE PLATE



Problem VI h

**Problem VIi.** This problem is similar to Problem VIh. It gives experience in spacing holes around a center.

**Problem VIj.** Honor Problem. This gives experience in working from a table of data. Your teacher will indicate the size of the bolt for which you will draw a flange.

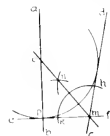


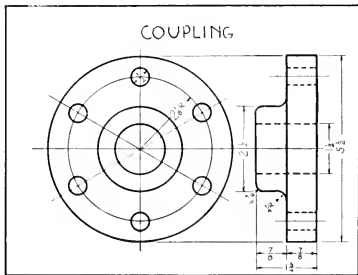
Fig. 34

To find the center of the arc in the side view consult Fig. 34. The line *ab* corresponds to the left vertical line in the side view of the flange; the line *cd* corresponds to the sloping line in the upper part of side view of the flange. The line *ef* is perpendicular to *ab* at the point *p*, which corresponds to the left end of the arc in the flange drawing. It is desired to find the center of a circle on *ab* which shall pass thru *p* and be tangent to *cd*. This means that we must find a point on the line *ab* which is the same distance from *p* that it is from the line *cd*.

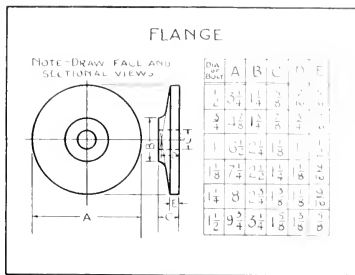
To do this bisect the angle between *cd* and *ef*. (1) With *m* as a center and any convenient radius draw an arc cutting the two lines at *g* and *h*. This gives us two points equally distant from *m*. (2) With these points as centers and any convenient radius, strike arcs intersecting at *n*. (3) Draw a line thru *m* and *n* intersecting the line *ab* at *o*. This point *o* is equally distant from the point *p* and the line *cd*. (4) With *o* as a center and *op* as a radius, draw the required arc.

**Problem VIk.** Honor Problem. This is the most difficult in the group because two arcs join each other at a tangent point. This requires especially accurate construction work. The problem also requires the finding of dimensions from algebraic formulae. But the problem is all the more interesting because of these facts.

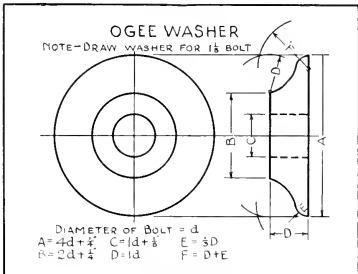
**Problem VII.** To help you in selecting an object to draw, the following list is given:—cutting board, sleeve board, bread board, hand-wheel, section of molding, hexagonal socket wrench.



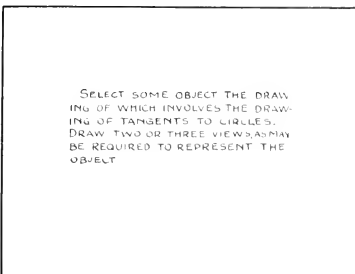
Problem VI I



Problem VI J



Problem VI K



Problem VI L

## GROUP VII

### WORKING DRAWINGS

**Problem VIIA.** A working drawing should be made from the standpoint of the workman. It should give the views that will help him most in visualizing the object, and give the dimensions he needs; and these should be placed where he can most easily find them. In making the drawing of the nail box you will take the same steps in the process that the draftsman usually takes in making a more complex drawing:—

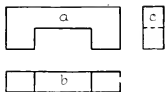


Fig. 35



Fig. 36

1. *Select Views.* In this case you need three views to show the object most fully and clearly—the top, front and end views. If this were a simple box without a handle, the top and front views would be sufficient. Fig. 35 shows three views, a, b and c, of a notched block in which the view c may be omitted. It tells nothing that needs to be known by the workman which is not told by the other two views. Fig. 36 shows how one view, with the thickness given in a note, may sometimes

take the place of two or three views. In the nail box you could omit the top view and transfer the dimensions in this view to the other two; you could omit some of these dimensions by making a note stating that the thickness of all stock except the bottom is  $1\frac{1}{2}$ "; but for an inexperienced workman the three views as shown are better than two.

2. *Determine the Scale.* The scale to which a drawing is to be made depends upon the size of the object, the size of the sheet of paper available, and the use to be made of the drawing when completed. In the case of the nail box you have one view 10" long and another  $4\frac{1}{2}$ " to be placed end to end on a sheet of paper that is  $10\frac{1}{2}$ " on the border line. It is obvious that you must make the drawing to scale. A little figuring will show you that you can use the scale 6" = 1', often spoken of as half size.

3. *Arrangement of Views.* In arranging the views, always place the top view above the front view, and the end or side view near the end or side where it is taken; that is, the right end view should be at the right of the front or top view, and the left end view at the left, Fig. 18. In spacing for these views remember that dimensions are to be added. At least  $\frac{1}{4}$ " of space

is needed for a line of dimensions. Where two lines of dimensions are to be placed on the drawing as is usually the case, at least  $\frac{1}{2}$ " should be left between views.

4. *Lines.* The lines used in making pencil drawings are the same as shown in Fig. 37.

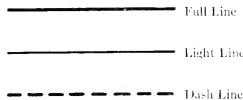


Fig. 37

5. *Lay-out.* Make the lay-out of the sheet as follows:

(a) Make the border lines as described in Problem IA.

(b) Make the lay-out of the views as described in Problem IA, or if it contains circles, as described in Problem VA. It is essential, as a rule, that center lines be drawn before circles, and that the circles be drawn before tangent straight lines, or straight lines projecting from circles.

6. *Lining in.* In lining in the drawing follow the order given in Problem VA, namely, (1) circles and arcs; (2) horizontal lines, beginning at the top of the sheet; (3) vertical lines, beginning at the left; (4) inclined lines, taking those of the same angle together.

7. *Selection of Dimensions.* There is one rule to follow in selecting dimensions: namely, put on the

dimensions that the workman will need in making the object. This rule is easy to state but difficult to follow. It is difficult because in order to select just the right dimension the draftsman must know, in general, at least, how the work is done. Moreover, in factories a drawing is often used by several different workmen, each doing a different part of the process of manufacture, and each wanting certain dimensions which may not be needed by all the others. In general we may say: (a) The over-all dimensions of the object are needed. These will show the size of the completed object. (b) The thickness, breadth and length of each individual piece of the object must be shown. These will be needed in getting out stock. (c) The dimensions of the parts of every joint must be shown. (d) The dimensions necessary to lay out the shape of any formed, modeled or irregular part must be given. (e) The location, size and depth of every hole must be shown.

A common device among draftsmen for meeting many of these conditions is to give parallel lines of dimensions, one line consisting of the total or over-all dimension, and the other the sub-dimensions; see end of top view in the drawing of the nail box. This device may be made to serve as a check on the draftsman's work because the sum of all the sub-dimensions in a given line must equal the total, or over-all dimension.

8. *Placing Dimensions.* Figs. 38, 39, 40, 41, 42 show different ways of placing dimensions. In nearly every working drawing there is one principal view—one that

tells more about the object than any other view. In this case it is the top view. The best rule for dimensioning in this particular case is to place the dimensions below and to the right of this main view, in so far as that is practicable. Fig. 38.—This brings the dimensions in groups between the views, where they are most easily seen, whichever view is the center of

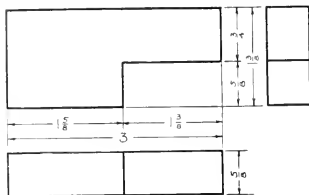


Fig. 38

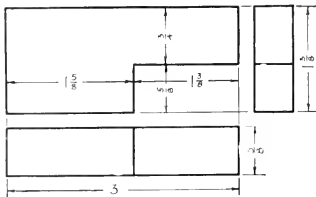


Fig. 40

attention. Sometimes the rule has been given to place the dimensions at the bottom and at the right of all views, Fig. 41, but this takes some of the dimensions too far away from the place where one naturally looks for them when centering his attention on the principal view.

In case the space between views is not sufficient to

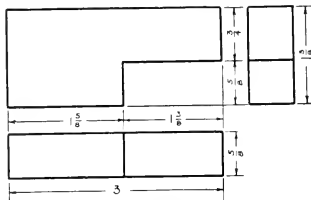


Fig. 39

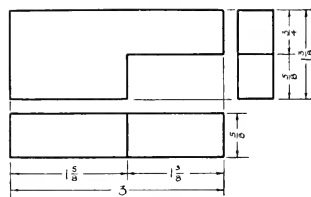


Fig. 41



allow of two lines of dimensions the arrangement in Fig. 39 has some advantages. If the views are so close together as to make it impossible to put any dimensions between them without crowding, the method shown in Fig. 40 is often used. This keeps the dimensions near the principal view, which is desirable, but it requires that two of the dimensions be placed on the

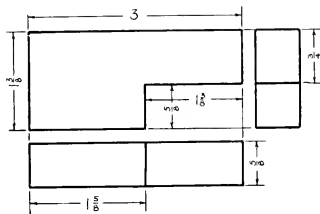


Fig. 42

view itself, which is not desirable. However, from the standpoint of the workman, the method shown in Fig. 40 is more desirable than that shown in Fig. 41. The method shown in Fig. 42 avoids placing any dimensions on the views, but scatters them so much that in general it is not as desirable as that shown in Fig. 40. From the above discussion it is clear that you should endeavor to so place your views that it will be possible to use the method of dimensioning shown in Fig. 38

9. *Figures.* The placing of the figures in dimensioning depends upon the space available. Fig. 43 shows

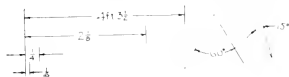


Fig. 43

correct placing of figures. In general all figures are placed parallel to the dimension line, and so they can be read from the bottom of the sheet or the right-hand end.

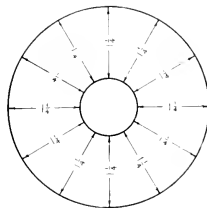


Fig. 44

When dimensions are run at odd angles it is sometimes a question how a dimension should be placed. Fig. 44 shows correct positions of figures at various angles.

**Problem VII B.** This problem involves finding the center of an arc that will pass thru three given points.

The construction necessary is shown in Fig. 15. The given points are a, b, and c. Using each point as a

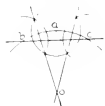


Fig. 15

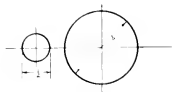


Fig. 16

center, strike intersecting arcs as shown. Straight lines thru the intersection points of these arcs meet at

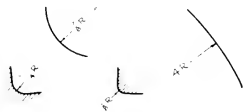


Fig. 47

the required point o which becomes the center for striking the arc a b c.

*Dimensioning Circles and Arcs.* Circles should be dimensioned by their diameters, Fig. 46. Arcs should be dimensioned by their radii, Fig. 47. Circles should be located by their centers, Fig. 48.

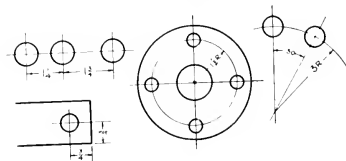
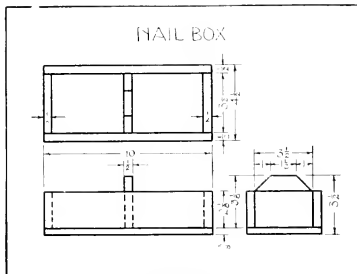


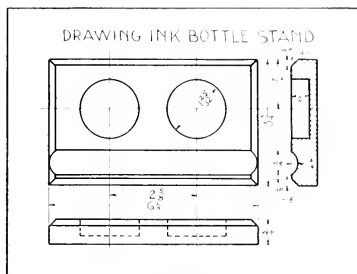
Fig. 48

**Problem VIIc.** The following are possible objects to draw: joint, bench-hook, bird house.

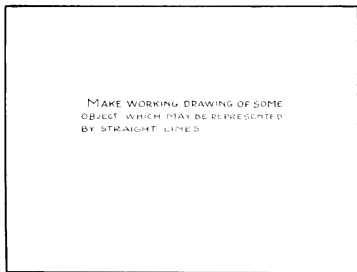
**Problem VIId.** The following are possible objects to draw: knife box, bracket shelf, cylinder head.



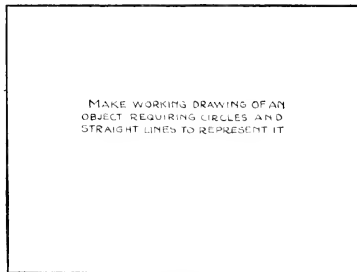
Problem VII A



Problem VII B



Problem VII C



Problem VII D

**Problem VII E.** This problem has been selected to show how an extra sheet of details may sometimes be used to advantage. It would have been possible to have placed all the dimensions of the detail sheet on the assembly drawing, but in that case the drawing would have been badly crowded. By adding the sheet of details greater clearness is obtained. Notice that all

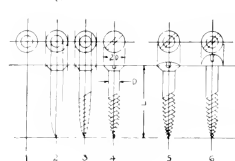


Fig. 49

dimensions of the top of the stool are found on the assembly drawing because the top is not shown on the detail sheet. Also notice that the method of as-

sembling the parts, namely, by screw, is shown in the assembly drawing. You will see that the screws are made with light lines in order not to give them too much prominence. Fig. 49 shows an approximate, but very convenient method of drawing screws. The lines of the threads are at an angle of  $60^\circ$  with the center line of the screw. The figures 1, 2, 3 and 4 indicate the stages in the process. The curve of the point is drawn freehand. Sometimes the last stage in drawing the threads is omitted, leaving them as in 3. The size of a screw is indicated by its length  $L$  and by its wire gage number, which means its diameter,  $D$ . The diameter of a screw, as found in the table of wire gage

sizes, is given in decimal form. For your convenience approximate sizes are given in Fig. 50.

These figures include only a few of the most commonly used sizes. The slot in the top view is usually drawn at a different angle from that in the front view, that is,

No.	App. Diam.
5	$1 \frac{1}{8}$
6	$\frac{9}{16}$
8	$\frac{5}{16}$
9	$\frac{11}{16}$
10	$\frac{3}{16}$
11	$\frac{13}{16}$
12	$\frac{7}{16}$
15	$1 \frac{1}{4}$

Fig. 50

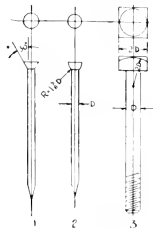
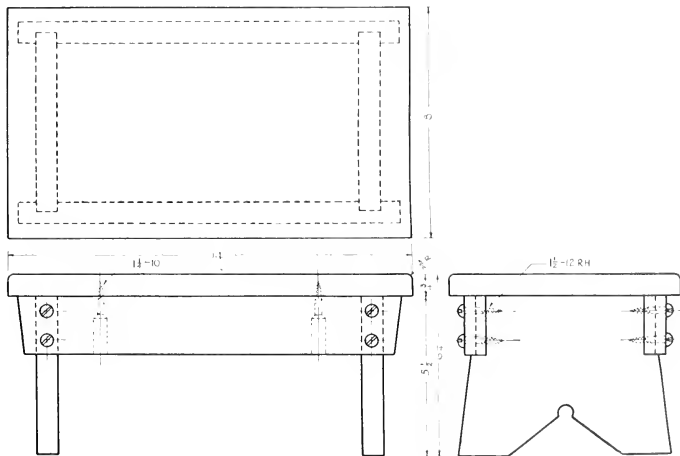


Fig. 51

at an angle of  $45^\circ$  to the horizontal. This avoids confusion with other lines in the top view. The front view of the head is drawn with angles of  $45^\circ$ , tho this is not the actual angle to which screws are made. It is, however, the most convenient angle to use in drawing. Screw 4 in Fig. 49 is called a flat head screw; screw 5 is called an oval head screw; and screw 6 is called a round head.

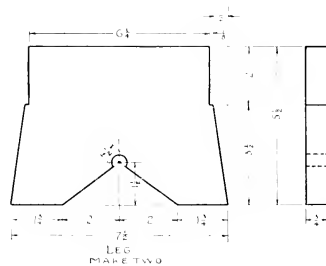
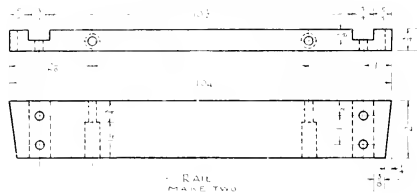
Fig. 51 shows easy ways of drawing wire nails and a bolt such as is used in woodwork. The head shown in 1 is that of a casing nail, in 2 that of a finishing nail.

## FOOTSTOOL



Problem VII E.

## FOOTSTOOL-DETAILS





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